Section 18.2

Objectives

- **Explain** how magma type influences volcanic activity.
- **Describe** the role of pressure and dissolved gases in eruptions.
- **Recognize** classifications of material ejected by eruptions.

Review Vocabulary

basaltic: relates to a group of rocks rich in dark-colored minerals containing magnesium and iron

New Vocabulary

viscosity
tephra
pyroclastic flow

Eruptions

MAIN Idea The composition of magma determines the characteristics of a volcanic eruption.

Real-World Reading Link Have you ever shaken a can of soda and then opened it? If so, it probably sprayed your hand, clothes, and maybe even your friends. This is similar to the process that underlies explosive volcanic eruptions.

Making Magma

What makes the eruption of one volcano quiet, and the eruption of another explosively violent? The activity of a volcano depends on the composition of the magma. As shown in **Figure 18.9,** lava from an eruption can be thin and runny or thick and lumpy. In order to understand why volcanic eruptions are not all the same, you first need to understand how rocks melt to make magma.

Temperature Depending on their composition, most rocks begin to melt at temperatures between 800°C and 1200°C. Such temperatures are found in the crust and upper mantle. Recall from Chapter 5 that temperature increases with depth beneath Earth's surface. In addition to temperature, pressure and the presence of water also affect the formation of magma.

Pressure Pressure increases with depth because of the weight of overlying rocks. As pressure increases, the temperature at which a substance melts also increases. **Figure 18.10** shows two melting curves for a type of feldspar called albite. Note that at Earth's surface, albite, in the absence of water, melts at about 1100°C, but at a depth of about 12 km, its melting point is about 1150°C. At a depth of about 100 km, the melting point of dry albite increases to 1440°C. The effect of pressure explains why most of the rocks in Earth's lower crust and upper mantle do not melt.

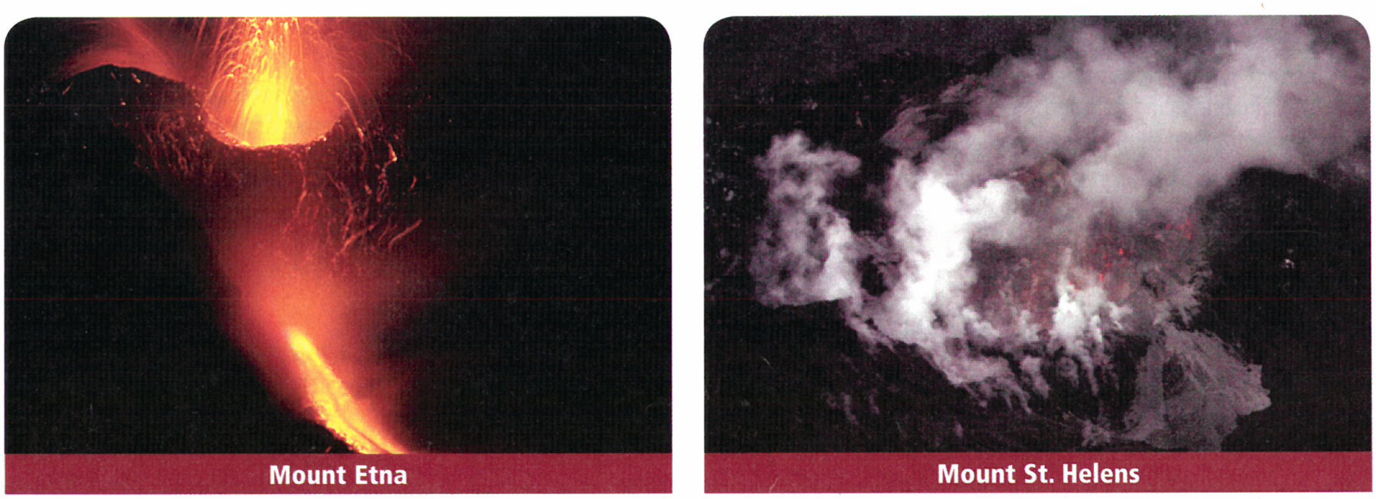


Figure 18.9 The way in which lava flows depends on the composition of the magma. Mount Etna's lava is thin and runny compared to the thick and lumpy lava that erupts at Mount St. Helens.

Composition of Magma

The composition of magma determines a volcano's explosivity, which is how it erupts and how its lava flows. What are the factors that determine the composition of magma? Scientists now know that the factors include magma's interaction with overlying crust, its temperature, pressure, amounts of dissolved gas, and—very significantly—the amount of silica a magma contains. Understanding the factors that determine the behavior of magma can aid scientists in predicting the explosivity of volcanic eruptions.

Dissolved gases In general, as the amount of gases in magma increases, the magma's explosivity also increases. In the same way that gas dissolved in soda gives the soda its fizz, the gases dissolved in magma give a volcano its "bang." Important gases in magma are water vapor, carbon dioxide, sulfur dioxide, and hydrogen sulfide. Water vapor is the most common dissolved gas in magma. The presence of water vapor determines where magma forms. As shown in **Figure 18.10,** minerals in the mantle, such as albite melt at high temperatures. The presence of dissolved water vapor lowers the melting temperature of minerals, causing mantle material to melt into magma. This eventually forms volcanoes and fuels their eruptions.

Viscosity The physical property that describes a material's resistance to flow is called **viscosity**. Temperature and silica content affect the viscosity of a magma. In general, cooler magma has a higher viscosity. In other words, cool magma, much like chilled honey, tends to resist flowing.

Reading Check Infer Which has a higher viscosity: syrup or water?

Magma with high silica content tends to be thick and sticky. Because it is thick, magma with high silica content tends to trap gases, which produces explosive eruptions. In general, magma with low silica content has low viscosity—it tends to be thin and runny, like warm syrup. Magma with low silica content tends to flow easily and produce quiet, nonexplosive eruptions.

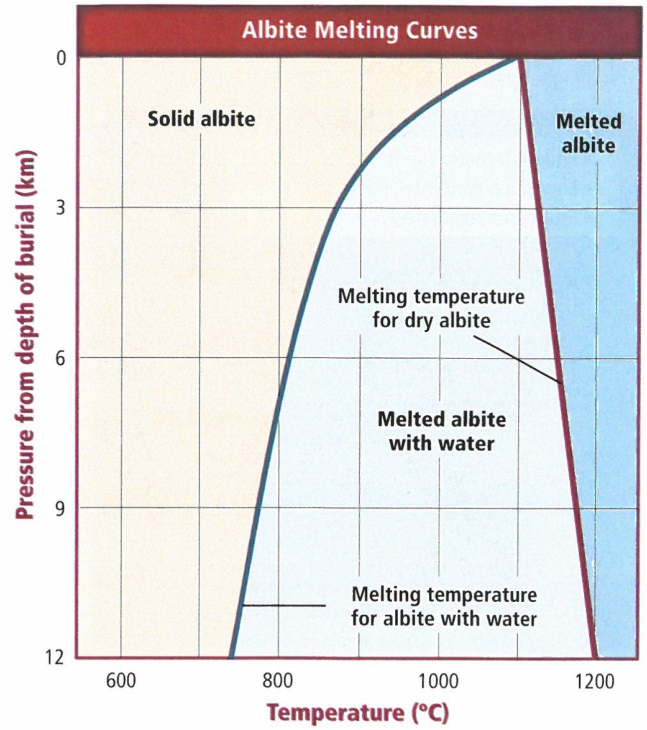


Figure 18.10 Both the pressure and water content of the mineral albite affect how the mineral melts.

Locate *the melting curve of wet albite. How does the melting point of wet albite compare to that of dry albite at a depth of 3 km? At a depth of 12 km?*

VOCABULARY

ACADEMIC VOCABULARY

Aid
to provide with what is useful or necessary in achieving an end
Glasses aid Omar in seeing clearly.

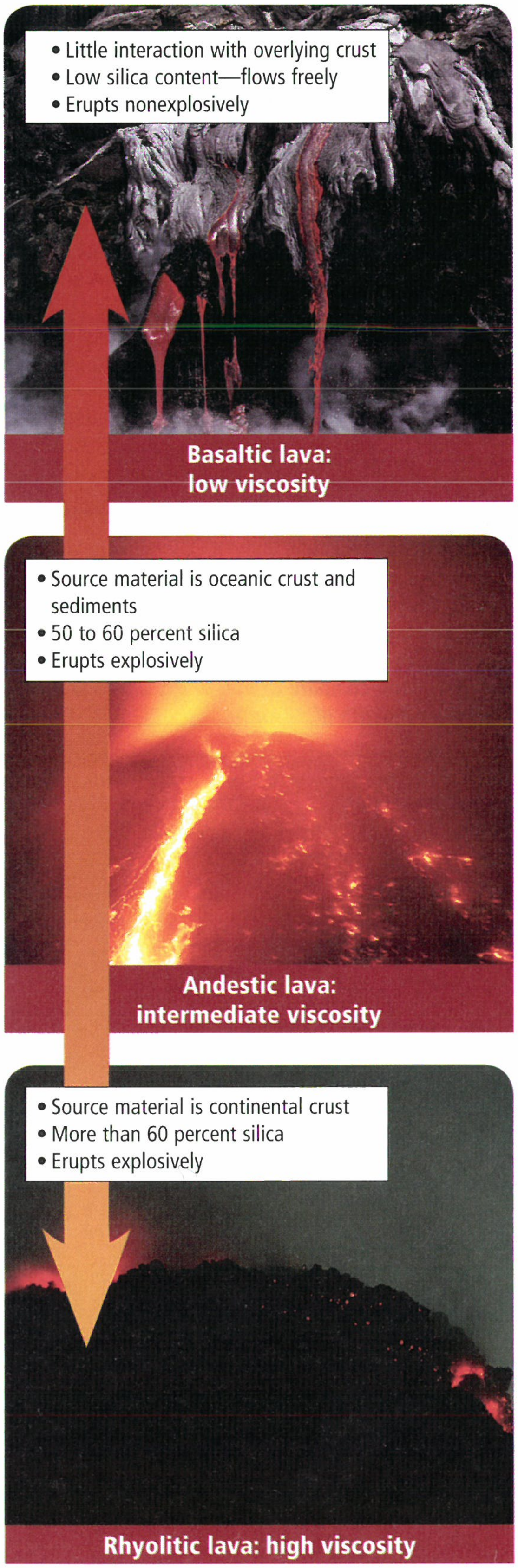


Figure 18.11 Generally, magma and lava with a low percentage of silica have low viscosity, and those with a higher percentage of silica have high viscosity.

Types of Magma

The silica content of magma determines not only its explosivity and viscosity, but also which type of volcanic rock it forms as lava cools. Refer to **Figure 18.11** to summarize types of magma.

Basaltic magma When rock in the upper mantle melts, basaltic magma typically forms. Basaltic magma has the same silica content as the rock basalt—less than 50 percent silica. This magma rises from the upper mantle to Earth's surface and reacts very little with overlying continental crust or sediments. Its low silica content produces low-viscosity magma. Dissolved gases escape easily from basaltic magma. The resulting volcano is characterized by quiet eruptions. **Figure 18.12** shows how properties of magma affect the types of eruptions that occur. Volcanoes such as Kilauea and Mauna Loa actively produce basaltic magma. Surtsey, a volcano that was formed south of Iceland in 1963, is another volcano that produces basaltic magma.

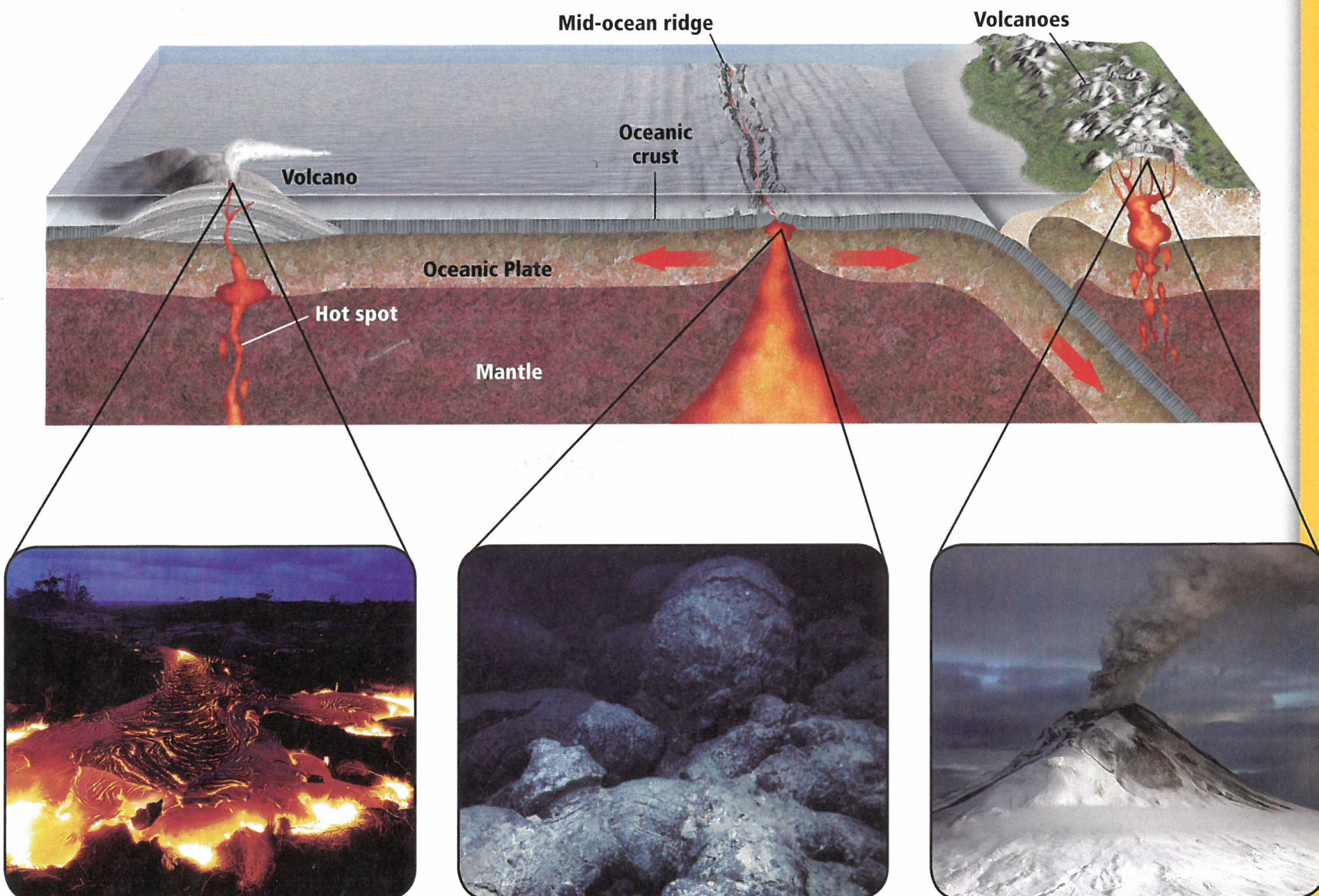
Andesitic magma Andesitic (an duh SIH tihk) magma has the same silica content as the rock andesite—50 to 60 percent silica. Andesitic magma is found along oceanic-continental subduction zones. The source material for this magma can be either oceanic crust or oceanic sediments. The higher silica content results in a magma that has intermediate viscosity. Thus, the volcanoes it fuels are said to have intermediate explosivity. Colima Volcano in Mexico and Tambora in Indonesia are two examples of andesitic volcanoes. Both volcanoes have produced massive explosions that sent huge volumes of ash and debris into the atmosphere. This not only devastated the local communities, but also impacted the global environment.

Rhyolitic magma When molten material rises and mixes with the overlying continental crust rich in silica and water, it forms rhyolitic (ri uh LIH tihk) magma. Rhyolitic magma has the same composition as the rock granite—more than 60 percent silica. The high viscosity of rhyolitic magma slows down its movement. High viscosity, along with the large volume of gas trapped within this magma, makes the volcanoes fueled by rhyolitic magma very explosive. The dormant volcanoes in Yellowstone National Park in the western United States were fueled by rhyolitic magma. The most recent of these eruptions, which occurred 640,000 years ago, was so powerful that it released 1000 km^3 of volcanic material into the air.

Visualizing Eruptions

NATIONAL GEOGRAPHIC

Figure 18.12 As magma rises due to plate tectonics and hot spots, it mixes with Earth's crust. This mixing causes differences in the temperature, silica content, and gas content of magma as it reaches Earth's surface. These properties of magma determine how volcanoes erupt.



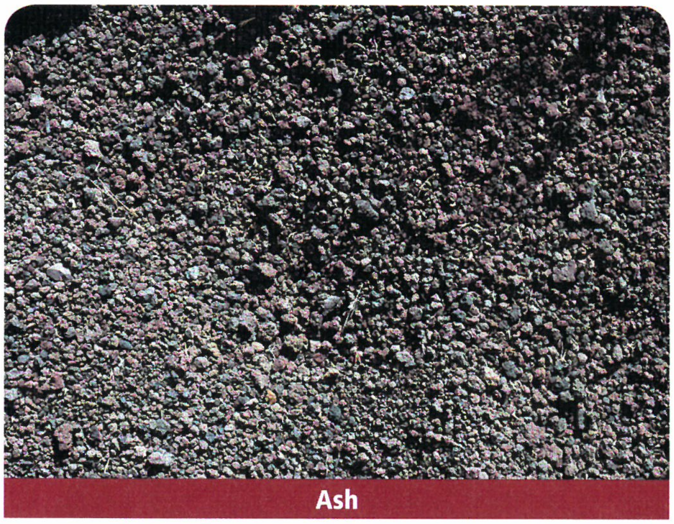
Quiet eruptions Earth's most active volcanoes are associated with hot spots under oceanic crust. Magma that upwells through oceanic crust maintains high temperature and low silica and gas contents. Lava oozes freely out of these volcanoes in eruptions that are relatively gentle.

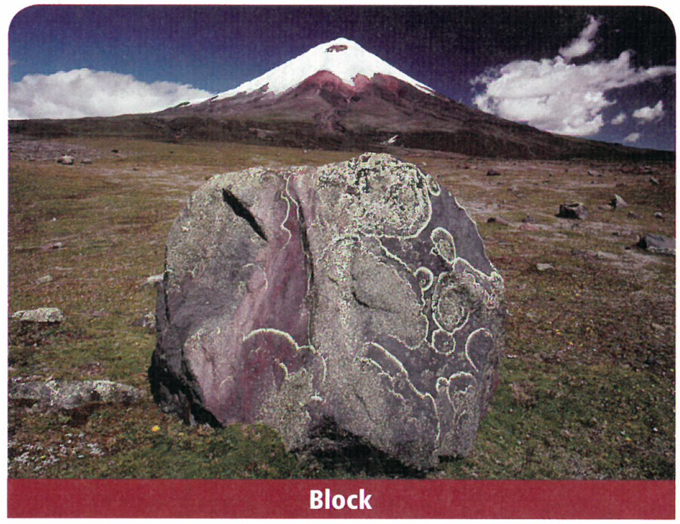
Underwater eruptions The most common type of lava on Earth is pillow lava. Most pillow lava forms at diverging plate boundaries along oceanic crust. Lava oozes out of fissures in the ocean floor and forms bubble-shaped lumps as it cools.

Explosive eruptions Dangerous eruptions occur where magma high in silica passes through continental crust. This magma traps gases, causing tremendous pressure to build. The release of pressure drives violent eruptions.

Concepts In Motion To explore more about plate tectonics resulting in volcanism, visit glencoe.com.

Earth Science Online





■ **Figure 18.13** Fine ash (shown actual size) is the smallest type of tephra. The 1-m-tall block shown here, ejected from Cotopaxi volcano in Ecuador, is an example of the largest category of tephra.

Compare *the two types of tephra. What do they have in common?*

Explosive Eruptions

When lava is too viscous to flow freely from the vent, pressure builds up in the lava until the volcano explodes, throwing lava and rock into the air. The erupted materials are called **tephra.** Tephra can be pieces of lava that solidified during the eruption, or pieces of the crust carried by the magma before the eruption. Tephra are classified by size. The smallest fragments, with diameters less than 2 mm, are called ash, as shown in **Figure 18.13.** The largest tephra thrown from a volcano are called blocks. The one shown in **Figure 18.13** is only about 1 m high, but some blocks can be the size of a car. Large explosive eruptions can disperse tephra over much of the planet. Ash can rise 40 km into the atmosphere during explosive eruptions and pose a threat to aircraft and can even change the weather. The 1991 eruption of Mount Pinatubo in the Philippines, shown in **Figure 18.14,** sent up a plume of ash 40 km high. Tiny sulfuric acid droplets and particles remained in the stratosphere for about two years, blocking the Sun's rays and lowering global temperatures.

■ **Figure 18.14** In 1991, the eruption of Mount Pinatubo in the Philippines sent so much ash into the stratosphere that it lowered global temperatures for two years.

Pyroclastic flow

1902 Eruption of Mount Pelée

Figure 18.15 A pyroclastic flow from Mount Pelée was so powerful that it destroyed the entire town of St. Pierre in only a few minutes.

Pyroclastic Flows

Some tephra cause tremendous damage and kill thousands of people. Violent volcanic eruptions can send clouds of ash and other tephra down a slope at speeds of nearly 200 km/h. Rapidly moving clouds of tephra mixed with hot, suffocating gases are called **pyroclastic flows.** They can have internal temperatures of more than 700°C. **Figure 18.15** shows a pyroclastic flow pouring down Mayon Volcano in Mexico in 2000. One widely known and deadly pyroclastic flow occurred in 1902 on Mount Pelée, on the island of Martinique in the Caribbean Sea. More than 29,000 people suffocated or were burned to death. What little was left of the town of St. Pierre after the eruption is shown in **Figure 18.15.**

Section 18.2 Assessment

Section Summary

- There are three major types of magma: basaltic, andesitic, and rhyolitic.
- Because of their relative silica contents, basaltic magma is the least explosive magma and rhyolitic magma is the most explosive.
- Temperature, pressure, and the presence of water are factors that affect the formation of magma.
- Rock fragments ejected during eruptions are called tephra.

Understand Main Ideas

1. MAIN Idea **Discuss** how the composition of magma determines an eruption's characteristics.
2. **Restate** how the viscosity of magma is related to its explosivity.
3. **Predict** the explosivity of a volcano having magma with high silica content and high gas content.
4. **Differentiate** between sizes of tephra.

Think Critically

5. **Compare and contrast** the tectonic processes that made Kilauea and Mount Etna.
6. **Infer** the composition of magma that fueled the A.D. 79 eruption of Mount Vesuvius that buried the town of Pompeii.

WRITING in Earth Science

7. Write a news report covering the 1902 eruption of Mount Pelée.

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